# An automated power of hydrogen controlled filtration system for enhanced aquarium fish farming

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**ABSTRACT**

The increasing popularity of fish keeping in aquariums and the need for electronic equipment to maintain an optimal environment. This article focuses on monitoring water purity to ensure fish health and longevity, addressing the issue of water pollution caused by chemicals and waste produced by fish. Solutions such as mechanical and biological filters are explored, highlighting the use of the mechanical filter composed of zeolite, ceramic rings, and activated carbon, which work to remove solid particles, toxic compounds, and pollutants from the aquarium water. The article presents the implementation of a mechanical filter controlled by a PIC18F4550 microcontroller using a pH sensor. The results indicate the stability of the pH of the water in the established range of 6.5 to 7.5, with a maximum error of 3% at the upper limit of the range and no error below the established lower limit. It is concluded that the system effectively maintains the desired levels and ensures the fish's health. A technological solution for monitoring and controlling water quality is presented, recognizing the possibility of improvements in aquaculture.



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## 1. INTRODUCTION

The breeding of fish in aquariums has become very popular [1]. Currently, electronic equipment is required for proper fish farming [2], as these are equipped with systems that monitor temperature [3] and purity level [2], [3]. All this is to maintain the health of the fish in optimal conditions [4], [5]. When fish are subjected to an aquarium, it must be similar to their natural environment since this favors their well-being and longevity [2], [6], [7]. It is also necessary to consider the group or family they belong to since each species has a different type of habitat [8]. Therefore, the guarantee of a good quality of life for these marine species lies in prioritizing temperature [6], [8], food [9], and water purity [2].

Contaminated water is one of the problems detrimental to proper fish breeding, as it contains chemicals that prevent proper survival [7], [10]. Therefore, the importance of continuous inspection of the purity level [2], [3], [11] to combat toxic chemicals originating from fish is emphasized [7]. The power of Hydrogen (pH) level is one of the most essential requirements for maintaining an optimal environment for fish [2]. In addition, the pH for most freshwater fish is maintained in the range of 6.5 to 7.5; however, this can be altered due to breeding depending on the type of fish [2]. Therefore, mechanical filters [12] and biological filters [4] are the most effective methods to avoid such imbalance [4].

Fish excretion is often constant, causing persistent variation in the purity level of the fish tank [3], [7], [10]. Likewise, plants have an impact on water quality by being part of a biological filter to neutralize water [10]–[12], as they absorb harmful compounds excreted by living organisms and food wastes, converting them into oxygen and increasing their size [4], [12], [13]. Chlorella is also mentioned for wastewater treatment, which is safe for fish, as it does not affect their immune system [14]. In addition, reference is made to the increased use of zeolite as an aquarium filter, which has become a significant trend in modern aquaculture due to its ability to maintain a clean and healthy aquatic environment without compromising fish health [15].

On the other hand, mechanical filters are crucial in keeping solid particles and debris from the water clean [16]. Certain filters use ceramic ring structures that provide a large surface area conducive to the growth of beneficial bacteria. These bacteria play a crucial role in the nitrogen cycle by transforming harmful compounds, such as ammonia and nitrites, into less harmful forms, such as nitrates [17]. In addition, other filters employ activated carbon due to its ability to absorb organic elements, chemical compounds, and specific contaminants in the water. This action contributes to eliminating impurities, foul odors, and dissolved organic wastes [18], [19].

On the other hand, the difficulty lies in that fish are susceptible to even small amounts of harmful substances originating from their feces [10], [14]. If the pH level is not controlled, this can cause fish death [2], [3]. Currently, many automated systems are using a microcontroller as the main memory for water monitoring [1], [2], [5], [20]–[25], although very few are dedicated to pH control [2], [7], [26]. Most research in this field has focused on the regulation of water movement and circulation in aquarium tanks [3], [9], [16], [20], [22], [27].

In summary, a mechanical filter composed of zeolite, ceramic rings, and activated carbon is implemented under the precise control of an analog-to-digital converter (ADC) of a microcontroller. The device collects data indicating variations in the water purity level in an aquarium and uses this information for filtration according to specific pH conditions. The main objective of this system is to maintain stability in the purity level of the aquatic environment, which is essential for fish farming.

## 2. METHOD

### 2.1. Material

The experiments were carried out in an aquarium designed specifically for domestic environments. This aquarium is notable for its compact size, small space, and stylized circuitry design, as shown in Figure 1. We used a pH-7BNC sensor, which evaluates the purity of water by measuring its acidity level. Generally, we aim to maintain a range of between 6.5 and 7.5 at most [2].

In addition, we incorporate a 16×2 liquid crystal display (LCD) model LM016L, which is responsible for presenting data in a 16-character format distributed in 2 lines on its screen. We used a PIC18F4550 microcontroller, a programmable chip that integrates a processing unit, memory, and input/output ports for electronics and control applications. Also, two 12 V water pumps were implemented to maintain a constant flow, together with two 12 V solenoid valves that allow the control of the water flow in the aquarium.

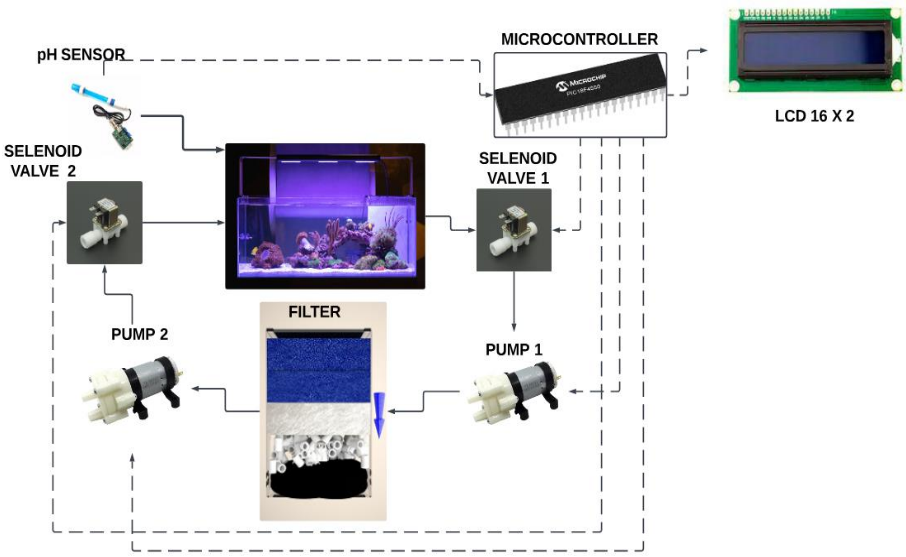


Figure 1. Operating diagram fluid direction black lines and broken lines circuit connection

### 2.2. Operation

The aquarium system has several key components, all supervised by a PIC18F4450 microcontroller. A purification process is activated when the water level reaches its maximum capacity. Before starting, the system checks if the pH sensor has exceeded the 7.5 threshold. If affirmative, the microcontroller sends a signal to pump 1 and solenoid valve 1, activating them to allow water flow to the filter, as shown in Figure 1. Once the water passes through the mechanical filter, composed of three layers (zeolite, ceramic rings, and activated carbon), pump 2 and solenoid valve 2 continue the flow of the water circulating through the filter, directing it back into the aquarium. This process will continue until the pH reaches 6.5 to 7.5; if it remains within this range, the pumps, solenoid valves, and filtration system will automatically stop. The pH values are displayed on the LCD screen, making it easy to observe the monitoring to keep the fish in a healthy environment. In addition, in Figure 1, the location of each component can be seen, with black dotted lines representing the wiring and black lines indicating the aquarium piping.

On the other hand, Figure 2 shows the logic of the algorithm with which the project operates. At startup, the system first verifies whether the pH level is within the established range, which goes from 6.5 to 7.5, according to the information obtained from the pH sensor. The pumps and solenoid valves are activated if the pH is not within this range. This action directs the water flow from the aquarium to the filter and back into the aquarium, thus initiating a recirculation process. This cycle continues until the pH value reaches the set range. Recirculation is not activated if the pH is already within the set range.

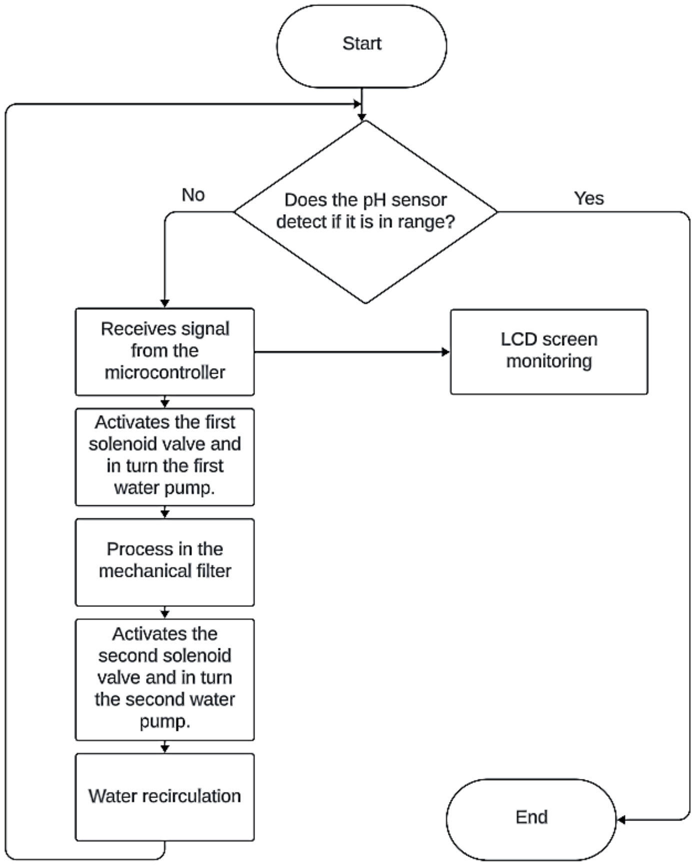


Figure 2. Aquarium water filtration and recirculation process flow chart

## 3. RESULTS AND DISCUSSION

Calibration of the pH sensor includes cleaning the electrode and immersing it in known solutions, adjusting the zero to pH 7.00 and the slope to pH 4.01 to ensure accurate measurements. After calibrating the sensor, we conducted tests by immersing it in the aquarium. We observed stability in the measurements during the first two days, as shown in Figure 3. However, we noticed increased pH by the third day due to fish activity. As the days passed, the action of the filtration system caused variations and a subsequent decrease in pH.

The test results indicate that the pH level of the water varies every two days. These variations are due to the range established by the sensor, which measures values within this range. Only when the values exceed 7.5 is the filtering process activated to control and monitor the pH, thus allowing water recirculation through the filter. Figure 3 analyzes the behavior of the values detected by the sensor on different days. It is observed that the blue line gradually adjusts to the desired range, with limits set at 7.5 as maximum and 6.5 as minimum. Although occasionally the values exceed the maximum limit due to organic waste generated by the fish, they never drop below the minimum value thanks to the action of the mechanical filter, as illustrated in Figure 3.

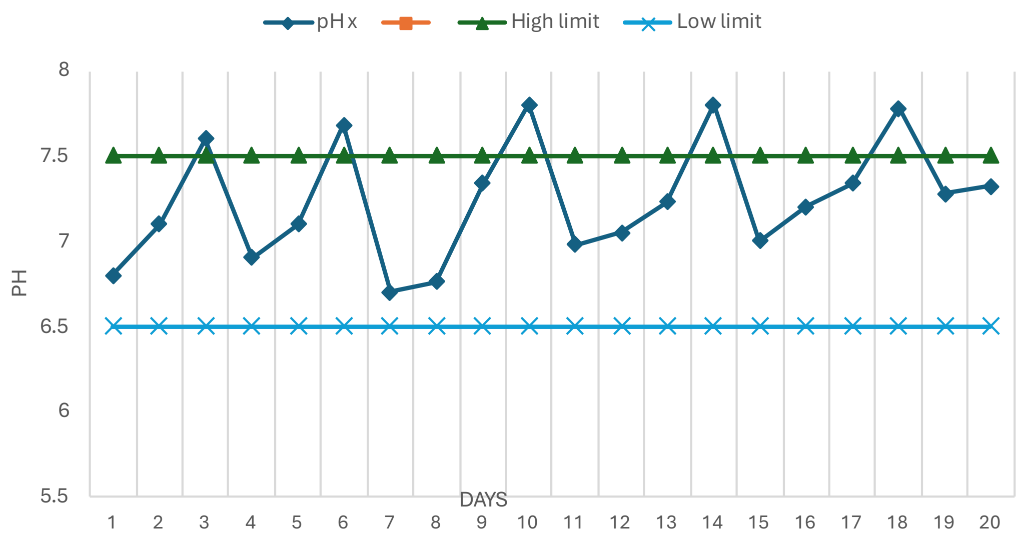


Figure 3. pH variation graph in the established range

In other articles, the facet to consider is that, upon initiating the control system, within 10 seconds, the pH level is lowered from 8.92 to 7.37 (within the accepted range of 6.5 to 7.5 pH). However, during the following 10 seconds, the pH sensor reading experiences an abrupt decrease, reaching a pH of 5.71, which leads to excessive acidity in the aquarium water [2]. In other words, the research above shows a maximum margin of error of 15.73% and a minimum margin of 12.15%. On the contrary, in our study, an error of 3.84% is recorded, thus exceeding the maximum limit established, which is 7.8 pH. In addition, the minimum limit does not register an error percentage since it does not fall below the value of 6.5 pH.

From a focal perspective, the focus is monitoring acidity levels, specifically pH and ammonia values, by implementing internet of things (IoT) technologies. The designated range for these measurements is set at 6.5 to 7.5 pH, where a light-emitting diode (LED) light signal is set when these limits are exceeded. This methodology demonstrates an accuracy of up to 100%. However, it is essential to note that the present investigation focuses exclusively on evaluating water acidity levels in the aquarium environment [28]. On the other hand, in our research, we evaluated pH levels and stabilized them within the established range by filtration. We used our recirculation system to prolong the use of aquarium water.

## 4. CONCLUSION

The article comprehensively addresses the challenges and solutions associated with aquarium fish farming, highlighting the importance of maintaining optimal conditions to ensure fish health and longevity. The implemented system, which combines a pH sensor, a microcontroller, and a mechanical filter, has proven to be. Effective in maintaining water pH levels within a desired range. This achievement is accomplished by increasing water recirculation through the mechanical filter only when pH values deviate from the set range. The system provides a solution to ensure the health and well-being of the fish by maintaining an optimal aquatic environment. It is also noted that the maximum pH level reached is 7.8, surpassing the upper limit of 7.5 (representing a 3.84% variation), and no minimum limit is recorded, as it does not drop below 6.5 pH, all thanks to the filtration process that prevents the imbalance of acidity and alkalinity levels.

Several areas of research and improvement can be identified for future studies. Optimization of the filtration system is one of them, where methods can be developed to improve filtration efficiency by considering different types of mechanical and biological filters. Adaptability to different fish species is also crucial; how the system responds to different species and their specific needs in terms of pH must be analyzed. In addition, validation in different environments is necessary: test the system in diverse aquatic environments, such as larger aquariums or commercial aquaculture environments. These suggestions for future research can contribute to advancing technology used in aquarium fish farming. This would improve fish health and welfare while optimizing the management of controlled aquatic environments.

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